

The First Infrared Beamline at the ALS: Design, Construction, and Commissioning

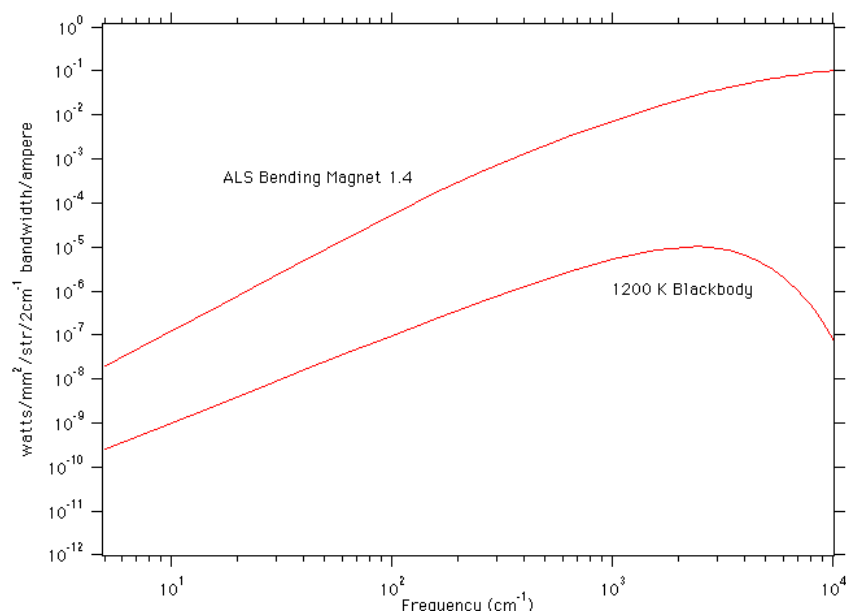
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INTRODUCTION

The bright continuous spectrum of radiation from all storage rings extends into the infrared (IR) region of the spectrum. In fact, within about two orders of magnitude, all synchrotron radiation sources provide an essentially similar source of IR light. While synchrotrons do not provide as much flux as a typical laboratory source, the highly collimated nature of the light allows more light to be routed through a smaller pinhole than when using any other continuum source. The cross-over point when the use of synchrotron radiation (SR) for microscopy becomes advantageous is at pinhole sizes of approximately 50 to 75 microns depending on the storage ring.

Figure 1 shows the brightness in $\text{watts/mm}^2/\text{str}/2\text{cm}^{-1}/\text{ampere}$ at the ALS with respect to a 1200 degree K blackbody. 2cm^{-1} is a typical bandwidth of a Fourier transform IR spectrometer (FTIR). It is quoted per ampere to allow for comparison with other rings. The maximum current at the ALS



is 400 ma. Clearly, for microscopy, the SR source is on the order of two to three orders of magnitude brighter than the blackbody source.

This abstract provides the overall layout of the beamline, and a description of the commissioning of the beamline.

Figure 1.

OVERALL LAYOUT

Figure 2 shows the layout of the beamline. The physical aperture in the storage ring is approximately 10 mr vertical by 80 mr horizontal. Only half of the horizontal aperture can be used, due to interference with a magnet downstream of the bending magnet. A water-cooled GlidcopTM aperture plate absorbs half of the radiation and passes the 10 mr vertical by 40 mr horizontal beam. The aperture plate is followed by a bellows and an all-metal valve which can shut only when the

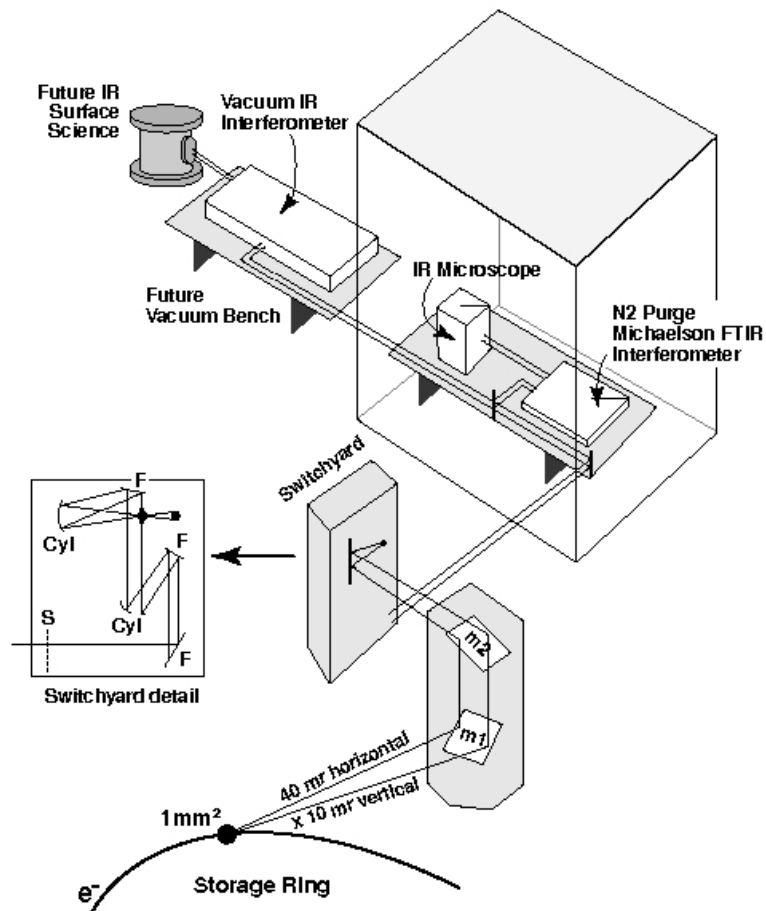


Figure 2. Layout of IR Beamline 1.4

storage ring is not running. (It would quickly overheat if closed during operation.) The first mirror (M1) is a water-cooled mirror of brazed GlidcopTM with an electroless nickel polished layer. The mirror is located three meters from the tangent point in the bending magnet. The mirror was fabricated at LBNL, and ground and polished by SESO of France. It is novel in that most of it is located outside the UHV chamber, and the mirror body itself forms the seal with the chamber, with an Helicoflex seal. Space considerations drove these choices, and there is considerable advantage to being able to change the mirror for coating and inspection. With proper tenting and dry nitrogen purge, the mirror can be removed during shutdown periods without the need to bake the system after re-installation. The incidence angle on the mirror (M1), 45 degrees, directs the radiation vertically upward onto an ellipsoidal mirror (M2). This is a Zerodur

mirror made by conventional techniques, also by SESO. It is placed in the same UHV chamber as M1, and directs the light 90 degrees tangentially to the storage ring and outside of the shielding wall. The 0.5 meter rise will allow future x-ray lines from the previous two bending magnets to pass under the IR beam. A five-inch hole in the shielding wall permits the beam pipe to pass without any lead shielding because of the 0.5 meter vertical difference between the hole and the ring. Measurements show essentially no radiation outside the hole during operation of the ring, and only minimal radiation during injection. The beam passes through a large ion pump just inside the shield wall.

Immediately outside the wall is a large, low vacuum box: the "switchyard." It can be positioned by a six-strut system. Only one rotation is motorized. The UHV extends a short distance into the switchyard. A small, flat mirror turns the radiation towards the microscopy hut and a diamond window. The diamond window, manufactured by Druker and sold by Harris corporation, is rated to withstand three atmospheres, and is the last UHV component. For additional protection, a small fused-silica-windowed valve with a Viton o-ring seal just before the switchyard shuts automatically if the vacuum fails in the switchyard. The diamond window is 12 mm in diameter and is placed at the focus of the ellipsoidal mirror. It is sealed in indium foil on both sides, and is polished with a one-degree wedge to remove possible extraneous interference fringes in the FTIR spectra caused by multiple reflections.

The M1/M2 chamber has two motions which can be controlled remotely using DC servo-motors. The chamber can be rotated about a vertical axis through the centers of the two mirrors, and the chamber can be moved up and down vertically to center M1 on the height of the radiated beam. M2 has pitch, roll, and yaw which can be adjusted only from inside the chamber.

Within the switchyard the radiation is allowed to expand four times as far in the 10 mr direction than in the 40 mr direction to allow the beam to be collimated by two separate cylindrical mirrors. This "squares up" the beam to a size which optimally fills one of two microscope objectives of 32x and 15x. There are two separate collimating/squaring sets of optics which can be moved in and out by motorized control under vacuum. Parallel beams approximately 6 mm square and 12 mm square leave the switchyard in the vacuum pipe which leads to the hutch. The cylindrical mirrors are precision optics from a vendor specializing in cylindrical optics.

In the hutch, plane mirrors inside the vacuum pipe lead to a KBr window or another wedged diamond window of 20 mm diameter. The low vacuum stops here and the radiation enters a dry air purged Nicolet 760 FTIR bench. The use of low vacuum all the way to the bench prevents noise from moving purge gas in the long run from the switchyard to the hutch. The bench is followed by a Nic-Plan all-reflective IR microscope with LN₂ cooled detector. The hutch has a small positive pressure from a HEPA filtered air source to keep some degree of cleanliness near the microscope and to provide a secure and isolated environment. Both instruments are supported by an optical table mounted on an interferometrically stable "six strut" kinematic support system which is successfully in use in throughout the ALS. A hand crank provides rotation of the entire table about the center of the first steering mirror in the transfer pipe at the corner of the table nearest the entrance of the beam, without sacrificing interferometric stability.

For pump-probe timing and IR surface science experiments we have obtained a vacuum FTIR bench from Bruker which will be placed on another table outside the hutch, identical to the one in the hutch which supports the microscope and FTIR bench. The vacuum plumbing is being extended through the hutch wall, onto this table, and into the vacuum instrument. Additional optical components will transfer the beam into an IR surface science experiment.

COMMISSIONING

The M1/M2 chamber was connected to the ring during a two-day shutdown. Synchrotron IR is now routinely in the IR microscope, producing a 10 μ m spot size. Synchrotron light has been admitted to the vacuum FTIR bench, and the timing and step-scan abilities of the instrument have been demonstrated with a timing signal from the storage ring. Formal operation of the beamline will commence on June 3, 1998.

SUMMARY

A state-of-the-art beamline for the extraction of IR radiation from a bending magnet at the ALS has been constructed, and is being commissioned. FTIR microscopy at higher spatial resolution than is available in the normal laboratory environment will be available to users. In addition, timing experiments and IR surface science experiments will be able to share the beamline after minimal further construction.

ACKNOWLEDGMENTS

Greg Vierra drew the layout of the beamline. At all stages of the development, Gwyn Williams and Larry Carr of the NSLS have generously provided the advantages of their extensive experience in IR beamline design and commissioning.

REFERENCES

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